NOGAP B.6; VOLUME 3: BEAUFORT SEA CURRENT MEASUREMENTS, SEPTEMBER 1987 - MARCH 1988

by

D. McCullough, R.W. Macdonald, K. Iseki, and E.C. Carmack

Institute of Ocean Sciences
Department of Fisheries and Oceans
Sidney, B.C.

1988

CANADIAN DATA REPORT OF HYDROGRAPHY AND OCEAN SCIENCES NO. 60

Canada

88-05791/

Canadian Data Report Of Hydrography and Ocean Sciences

These reports provide a medium for the documentation and dissemination of data in a form directly useable by the scientific and engineering communities.

Generally, the reports will contain raw and/or analyzed data but will not contain interpretations of the data. Such compilations will commonly have been prepared in support of work related to the programs and interests of the Ocean Science and Surveys (OSS) sector of the Department of Fisheries and Oceans.

Data Reports are produced regionally but are numbered and indexed nationally. Requests for individual reports will be fulfilled by the issuing establishment listed on the front cover and title page. Out of stock reports will be supplied for a fee by commercial agents.

Regional and headquarters establishments of Ocean Science and Surveys ceased publication of their various report series as of December 1981. A complete listing of these publications and the last number issued under each title are published in the *Canadian Journal of Fisheries and Aquatic Sciences*, Volume 38: Index to Publications 1981. The current series began with Report Number 1 in January 1982.

Rapport statistique canadien sur l'hydrographie et les sciences océaniques

Ces rapports servent de véhicule pour la compilation et la diffusion des données sous une forme directement utilisable par les scientifiques et les techniciens.

En général, les rapports contiennent des données brutes ou analysées mais ne fournissent pas d'interprétations des données. Ces compilations sont préparées le plus souvent à l'appui de travaux reliés aux programmes et intérêts du service des Sciences et Levés océaniques (SLO) du ministère des Pêches et des Océans.

Les rapports statistiques sont produits à l'échelon régional mais sont numérotés et placés dans l'index à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page de titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Les établissements des Sciences et Levés océaniques dans les régions et à l'administration centrale ont cessé de publier leurs diverses séries de rapports depuis décembre 1981. Vous trouverez dans l'index des publications du volume 38 du *Journal canadien des sciences halieutiques et aquatiques*, la liste de ces publications ainsi que le dernier numéro paru dans chaque catégorie. La nouvelle série a commencé avec la publication du Rapport n° 1 en janvier 1982.

Canadian Data Report of Hydrography and Ocean Sciences No. 60

1988

NOGAP B.6; VOLUME 3: BEAUFORT SEA CURRENT MEASUREMENTS, SEPTEMBER 1987 - MARCH 1988

by

D. McCullough, R.W. Macdonald, K. Iseki, and E. C. Carmack

Institute of Ocean Sciences
Department of Fisheries and Oceans
Sidney, B.C.

Copyright Minister of Supply and Services Canada - 1988
Cat. No. Fs 97 – 16/60 ISSN 0711-6721

Correct citation for this publication:

McCullough, D., R.W. Macdonald, K. Iseki, and E.C. Carmack, 1988. NOGAP B.6; Beaufort Sea current measurements September 1987 - March 1988
Can. Data Rep. Hydrogr. Ocean Sci.: 60(3). 37pp

Contents

1 INTRODUCTION 1
1.1 Stations 1

2 METHODS 1
2.1 Instrumentation 1
2.2 Mooring Design, Deployment and Recovery 3
2.3 Calibration 6

3 DATA PROCESSING 7
3.1 Procedures 7
3.2 Data display 7

4 References 8

5 APPENDIX 1; TIME SERIES U-V STICK PLOTS 9

6 APPENDIX 2; PROGRESSIVE VECTOR PLOTS 19

7 APPENDIX 3; 10 DAY AVERAGES PLOTS AND TABLES 27

Abstract

McCullough, D., R.W. Macdonald, K. Iseki, and E.C. Carmack, 1988. NOGAP B.6; Beaufort Sea current measurements September 1987 - March 1988
Can. Data Rep. Hydrogr. Ocean Sci.: 60(3). 37pp

As part of the NOGAP B6 program, with major objectives to determine hydrocarbon pathways and primary productivity of the waters overlying the Mackenzie Shelf, four subsurface taut-line moorings were deployed in the summer of 1987 along the 200 meter contour in the Beaufort Sea. Each mooring comprised a pair of current meters and a sequential sediment trap. One current meter was located as close to the surface as predicted ice keel depths would allow and the other was 50 meters above the bottom in close association with the sediment trap. The moorings were recovered from the ice in March 1988. The measurements are summarized in this report as time series plots. at fixed depths, of temperature, salinity, current speed, current direction and light transmission.

Key words: Arctic, Beaufort Shelf, oceanography, currents, temperature, salinity, light transmission, time series.

Résumé

McCullough, D., R.W. Macdonald, K. Iseki, and E.C. Carmack, 1988. NOGAP B.6; Beaufort Sea current measurements September 1987 - March 1988
Can. Data Rep. Hydrogr. Ocean Sci.: 60(3). 37pp

En été 1987, quatre amarrages ont été enstallés sur le contour de 200 mètres dans la mer de Beaufort, dans le cadre du programme NOGAP B.6, avec les objectifs principaux la détermination des trajectoires des hydrocarbures et de la production primaire des eaux au-dessus du plateau continental Mackenzie. Chaque amarrage consistait en deux courantomètres et d'un capteur de sédiments. Un des courantomètres était situé aussi près de la surface que permis par les profondeurs des quilles formées sous une crête de pression, l'autre 50 mètres au dessus du fond, près du capteur de sédiments. Les amarrages ont été récupérés pendant le printemps 1988. Ce rapport résume les mesures sous la forme des séries chronologiques, à profondeurs prescrits, de la temperature, de la salinité, de la vitesse et direction de courant, et de la transmission de lumière.

Mots-clé: Arctique, plateau continental de Beaufort, océanographie, courants, température, salinité, transmission de lumière, séries chronologiques.

Acknowledgements

This work was funded by **Indian and Northern Affairs, Canada**, as part of the **Northern Oil and Gas Action Program**. We thank S. Moorhouse, and Peter Gamble for field support, T. Warnes of Computing Services, and H. Melling for computing and scientific advice. In addition, thanks are due to the officers and crew of the C.S.S. *John P. Tully* for mooring deployment support and to Energy, Mines and Resources, Polar Continental Shelf Project in Tuktoyaktuk, N.W.T. for accommodations and technical assistance during recovery operations. S. Thomson assisted with advice on report layout. A. Ages translated the abstract into french. The manuscript was prepared using LaTeX.

1 INTRODUCTION

As part of an interdisciplinary study (NOGAP B.6) to measure the transport and fate of hydrocarbons over the Beaufort Shelf, and primary productivity of these coastal waters, we deployed 4 subsurface moorings along the 200 metre isobath at locations ranging from the Mackenzie Canyon to Cape Bathurst. The moorings were initially deployed, using ski-equipped aircraft support, from the ice cover in the spring of 1987 and were recovered and redeployed during the summer open water season from a government survey vessel. All four moorings were successfully recovered during aircraft-supported ice operations in March 1988. The centerpiece instrument on each mooring was a sequential sediment trap designed to obtain, by catching particle fallout, a record which would contain within it the seasonal productivity cycle for the duration of the deployment. The data and descriptions of the sediment traps will be detailed elsewhere and therefore will not be covered in this document. Above and below the sediment traps, self-recording current meters were installed to provide information about currents and water properties which can be used to identify water masses and transport. This report presents current, salinity, temperature, and light transmissivity data in tabular or graphic form for the latter half of the mooring program (Aug 87 - Mar 88). Data records for the first half of the program (Mar 87 - Aug 87) are to be found in *McCullough et al*; [1988].

1.1 Stations

Figure 1 shows the locations of the moorings along the 200 metre shelf contour. The initial installations were undertaken during the spring (two in March, one in April, one in May, 1987) from the sea-ice, therefore exact sites were dictated by ice conditions in the area of interest. The position of the mooring was taken at anchor set-down from fixes generated by a portable satnav system. A satnav system was also used on the *John.P. Tully* to occupy the stations for the recovery operations. When the moorings were originally deployed from the sea-ice, mooring length was adjusted to reflect the changing water depth as the ice floes drifted during the deployment activities. Line lengths were extended at stations SS-1 and SS-4 as water depth increased to 210 and 268 metres respectively during deployment. At stations SS-2 and SS-3 moorings were shortened to match decreased water depth of 170 and 180 metres. When the installations were redeployed from the survey vessel in August 1988 the two extended moorings (SS-1 and 4) were shortened to match the original design specifications for 200 metre water and then relocated a short distance to be released at the appropriate depth. The shortened moorings were left as is and deployed at depths matching those of the preceding spring. The most significant site relocation took place at SS-4 where the mooring was moved approximately 19 kilometres to the south-east to 200 m from 268 m. Table 1 summarizes the locations for the second series of deployments. Precision of the satnav system is within 300 m of the true geodetic location. In all cases we were able to navigate to within 1 km (acoustic range) when retrieving the moorings

2 METHODS

2.1 Instrumentation

In total, 8 arctic modified Aanderaa Instrument Ltd. Recording Current Meters (RCM4's) were deployed. Sampling intervals in all cases were set to 60 minutes, allowing over one year's data collection.

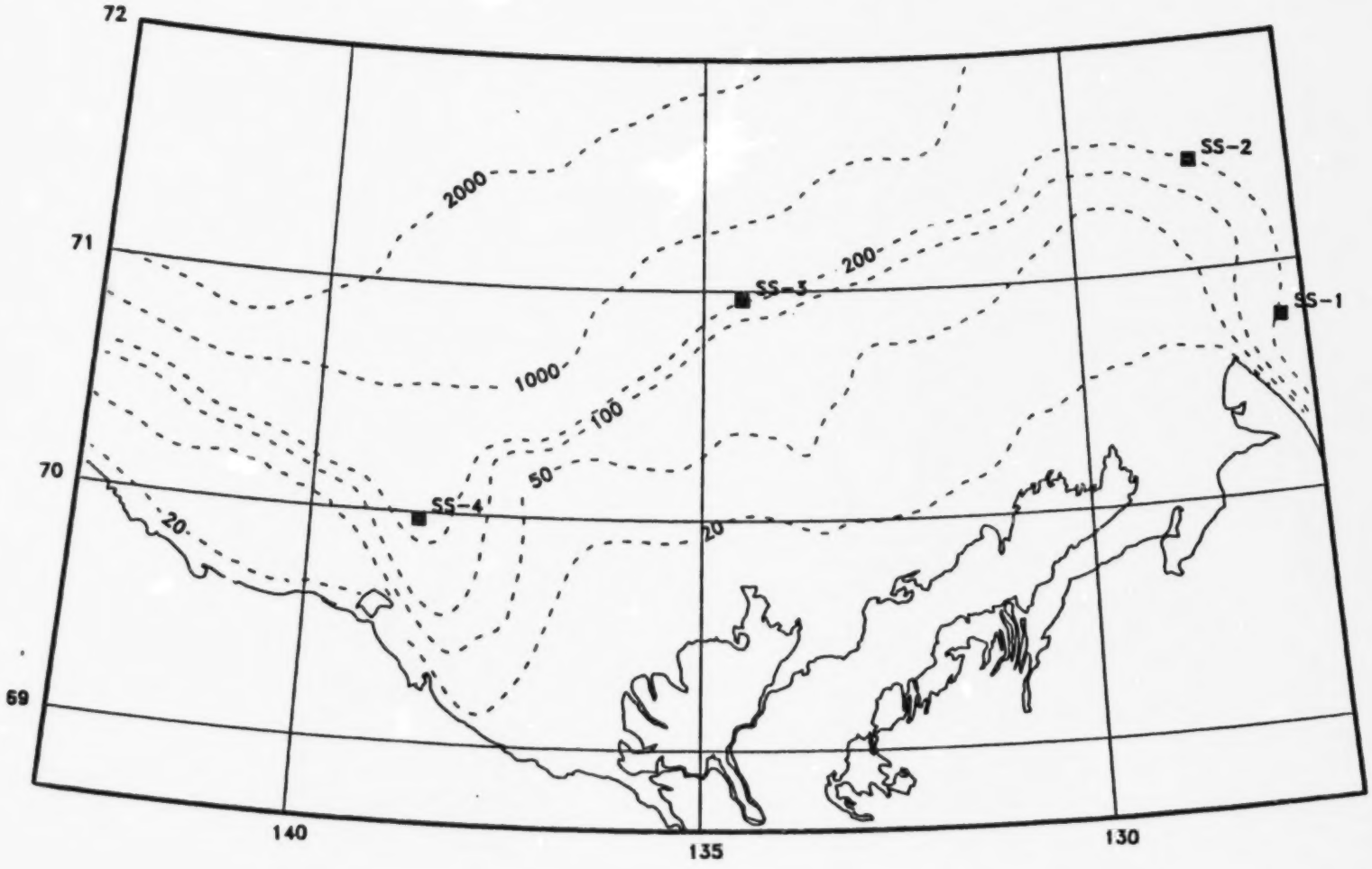


Figure 1: Mooring Locations

Table 1: Mooring Station Summary

Site	Latitude	Longitude	depth (m)
SS-1	70° 45.8'N	127° 23.6'W	200
SS-2	71° 27.3'N	128° 39.8'W	170
SS-3	70° 57.2'N	134° 23.9'W	183
SS-4	69° 51.0'N	138° 29.6'W	200

Table 2: Summary of Recording Instruments (RCM4)

Site	S/N	Depth (m)	Deployment Date(d/m/y)	Recovery Date(d/m/y)	Comments
SS-1	7906	35	23/08/87	23/03/88	Partial Record
SS-1	7914	150	23/08/87	23/03/88	
SS-2	7911	35	25/08/87	24/03/88	
SS-2	7915	120	25/08/87	24/03/88	
SS-3	7907	35	19/08/87	20/03/88	%TX
SS-3	7916	133	19/08/87	20/08/88	No speed data
SS-4	7913	35	27/08/87	25/03/88	
SS-4	7918	150	27/08/87	25/08/88	

† % TX refers to instruments equipped with transmissometers.

Modifications to the RCM4's were as follows: circuit board resistors for temperature and conductivity were changed to increase the resolution of the sensors and restrict the measurement range to encompass the expected values in the defined study regions. The temperature range was set to -2.5 ^{o}C to +2.5 ^{o}C with a resolution of about 0.005 ^{o}C. Salinity range was 29 to 35 with a resolution of 0.006[1]. The current meter cases were lengthened to accommodate an extra battery, a desirable feature for long deployments in cold waters. Two of these instruments were re-configured (at Aanderaa Instruments ltd.) to accommodate Sea Tech Inc., transmissometers which measured percent transmission (%TX) of red (660 nm) light over a 25 cm path length. These meters were deployed with the shallow current meters at sites SS-1 and SS-3. The data from these units were logged on channel 4 of the RCM4 datalogger and recorded with the other parameters on magnetic tape. Power for the transmissometer and its circuitry within the RCM4 was provided by a pair of internal AA size lithium batteries.

2.2 Mooring Design, Deployment and Recovery

All four moorings were single point, taut-line designs with train wheel anchors and subsurface flotation. The 200 meter isobath was selected for deployment, because along much of the Beaufort shelf it coincides with sharply increasing water depths and can be considered to approximate the beginning of the "Shelf Break". Figure 2 is a representative schematic of the mooring configuration used at the 4 sites. Mooring plans for the year's program included deployment in the spring during

[1] In this report no units of salinity are used. The numbers given are salinity $\times 10^{-3}$

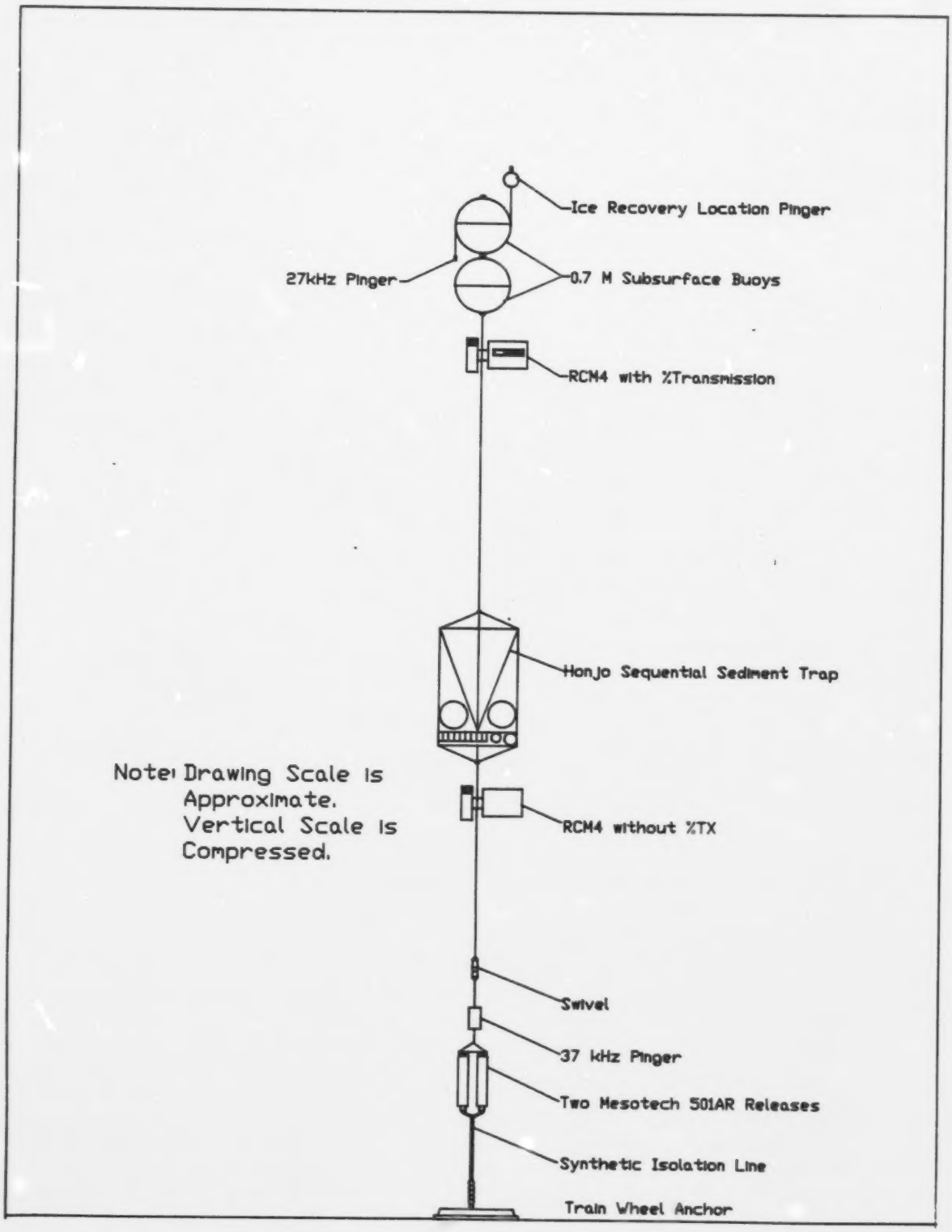


Figure 2: Mooring Configuration

ice operations, with recovery and subsequent re- deployment, from a survey vessel, during the summer open water season. Mooring designs and deployment/recovery techniques differ considerably between sea-ice and sea-going programs, it was therefore necessary to design these arrays to work with both methods.

To insure proper instrument configuration within the water column, the moorings were computer modeled to fit various design options open to us. A current velocity profile was determined, for the water column, through consultation with recognized authorities on Beaufort Sea current structure. Historical current measurements made in the region were used to generate a representative profile; for all four locations we expected currents in the top 50 m of the water column to be 50 cm/s and a reduced speed of 25 cm/s from 50 m to the bottom (200 m). Anchor weights, horizontal and vertical forces, and mooring tilts were computed using these estimated current speeds. Moorings were modeled on an IBM-XT personal computer with software derived from algorithms and computations documented by *Bell*, [1977].

The original mooring designs were to a great extent dictated by the logistics and problems associated with deployment from the ice cover during winter conditions. Anchor and buoy specifications are reduced to safe minimums to decrease load and space requirements for transport to the installation site in small charter aircraft. For a sea-going deployment, where shipping space is relatively unlimited, moorings can often be over-built with more flotation and anchor weight to insure a large safety factor in mooring dynamics such as tilt angle and excursion. The second deployment of our moorings was undertaken from a large vessel; however the basic design was changed very little because their subsequent recovery was intended to take place from the sea-ice. All the equipment would again have to be transported back to the base camp in Tuktoyaktuk by charter aircraft.

Only two significant changes were made to the original design during the mooring refit on the *John.P. Tully*. The ice deployment was done using separate links of 7 cm stud link chain, each weighing approximately 22 to 27 kg. The links were easy to man-handle and could be chained together to form a clump weighing the necessary 350-400 kg. For ship deployment the anchor was changed to a single 360 kg train wheel, a mass which was easily handled with the crane and winches available on the ship. The vertical distribution of the subsurface buoys was changed to simplify the future ice recovery of the equipment by moving the lower 0.7 m float up and coupling it to the top float. This is so that, upon recall, the mooring comes up under the ice with the line and instruments are all hanging straight down below the floats. The array can then be easily brought up through the recovery hole. If the buoys are located at the top and near the bottom of the mooring as in the original arrangement [*McCullough et al*; 1988] the mooring could come to the surface with the floats on either side of an ice keel. This complicates the process of retrieval because the float must be depressed under the submerged ridge before it can be brought to the melt hole. The disadvantage of moving the lower float is the loss of backup floatation in the event the top buoy is torn away by an ice keel. This possibility is much reduced if the floats are kept below the estimated maximum keel depth.

Ice keels form the subsurface portion of pressure ridges which develop when two moving ice floes impact one another. The best estimates for average ice keel depths can be derived from seabed surveys done in many locations on the Beaufort shelf. Side scan sonar, echo sounder and shallow seismic records clearly exhibit ice scour evidence, caused by grounded ice keels, in water depths up to 80 m. These deep water scours are recognized, in most instances, to be very old (Paleoscour) and may have been formed during periods of significantly lower water levels [*Gilbert and Pederson*; 1986]. Recent scours begin to increase in frequency at about the 40 m depth contour suggesting ice keels of this draft to be a more common maximum [*Barnes et al*; 1984]. To avoid interaction between the upper subsurface float on the mooring and passing ridge keels we attempted to position

the floats deeper than 30 metres.

2.3 Calibration

Current meters were deployed with sensors for current speed, direction, water temperature, and conductivity. Two of the meters were modified to accept data from transmissometer mounted in the directional vanes.

As long as the Savonius speed sensor is in good condition and the bearings are well maintained and adjusted there is no need to calibrate this sensor. Rotational thresholds were tested, before and after deployment, following Aanderaa methods and confirmed to be within factory specifications. Accuracy for this sensor is given as ± 1 cm/s.

The direction sensing compass located in the base of the pressure case, provides a magnetic bearing of current direction at the time of sensor sampling. All magnetic screws and fittings in the vicinity of the compass are removed and non-magnetic batteries are installed to reduce error. The geomagnetic flux in the Beaufort Sea area exhibits a strong vertical component due to the proximity of the north magnetic pole ($\approx$1700 km N.E.) where the magnetic inclination is 90° [*Merrill and McElhinny*, 1983]. The accuracy of a standard magnetic compass such as the one used in the RCM4 current meter is adversely affected by the vertical component of the earth's magnetic field at high latitudes. In an effort to quantify the induced error caused by inclination, all the instruments were calibrated in Tuktoyaktuk against a precision reference compass. The current meter was mounted, complete with pressure case, on a turntable, compass output was recorded at 20 degree intervals for comparison to the reference unit. Variance between the units was logged and correction constants were determined for input to final compass calibration equations at the time of data processing. The factory-defined error for RCM4 compasses is $\pm 5°$ under the best conditions, an additional 5° error is estimated, given the geomagnetic difficulties associated with Arctic latitudes. The result is an approximate $\pm 7°$ imprecision (RMS) for all current directions as published in this report. Magnetic current vectors were converted to true bearings by adding the estimated compass declination for each site to the current direction records.

Temperature sensors on each instrument were calibrated in a saltwater bath. Temperature inside the insulated bath container was controlled to within 0.002 °C. Sensor output was recorded at 6 or 7 points across its range, and a polynomial equation fitted to derive calibration coefficients. Bath temperature checks during the progress of the calibration were provided by a platinum resistance thermometer which verified that accuracy and precision equal the resolution of 0.005 °C.

Conductivity sensors on the current meters were calibrated in the same bath at three different conductivities within the measurement range of the cell (typically 20 to 30 mmhos/cm). The salinity of the bath was determined by analyzing samples on a Guildline Autosal salinometer. Then a linear equation for conductivity was fitted to the points and calibration coefficients were determined. These methods result in an estimated accuracy of ± 0.1 at a precision of ± 0.03.

Calibration of the transmissometer/RCM4 packages was performed according to the Sea Tech Inc. instruction manual. The transmissometer was connected to the RCM4 and the output on data channel 4 was recorded during the test. The lenses were cleaned and a voltmeter was attached to the transmissometer output. The voltage and corresponding RCM4 binary output were recorded for an unblocked and blocked light path. This "air calibration" furnishes values for 0% and 100% transmission and a linear coefficient for interpreting the collected data after recovery. Stated accuracy for this instrument is ± 0.5 percent transmission.

Table 3: Estimated Accuracy of Measured Parameters

Parameter	Accuracy	Precision	Resolution
Speed (cm/s)	±2%	±7%	0.05
Direction (°True)	±5	±7	0.35
Temperature (°C)	±0.005	±0.005	0.005
Conductivity Ratio	±0.0025	±0.0008	0.00016
% Transmission	±0.5	±1.0	0.3

3 DATA PROCESSING

3.1 Procedures

When the current meter data tapes were returned from the field the first step in processing was to translate the records from the 1/4 inch field tapes to a hard-disk equipped, IBM-XT, desk- top computer. The translation interface was an Applied Microsystems Ltd. model 769D which read from a Sony reel to reel tape recorder. The data records were then transmitted to the Institute of Ocean Sciences, Central Computing, Vax 11/785 for storage on 9 track magnetic tape and data processing. Each current meter file was then edited to check the instrument timing, delete pre- and post- deployment data cycles and remove obvious data "spikes". Header files containing information specific to each instrument including timing, mooring location, calibration coefficients, and comments were generated and attached to the data. The raw data values or "N" numbers were then corrected and converted to appropriate engineering units through application of formulae and coefficients produced during pre-deployment laboratory calibrations.

Salinity was computed from calibrated values for temperature, conductivity, and sensor depth. Only one instrument had a pressure sensor, therefore elevation was calculated from measured water depth and known mooring segment lengths. Sounder errors in 200 m of water and other methodological inaccuracies result in approximate elevation imprecisions of ±3 m. Salinity was calculated from conductivity using the Practical Salinity Scale 1978 [*Lewis and Perkin*; 1978].

3.2 Data display

Appendices 1 to 3 present the calibrated and corrected current meter data. Appendix 1 contains time series plots of daily averaged data for each instrument. Current velocity is displayed as North/South (V) and East/West (U) components and combined (U,V) stick plots where stick length and inclination depict speed and direction respectively. Due to page space limitations, light transmission records for station SS-3 are plotted separately with the matching stick plot. The transmissometer equipped current meter at station SS-1 (35 m) malfunctioned after 11.5 days. The data recorded before the stoppage have been processed and plotted with the exception of % TX, which averaged about 90% for the duration and 16 day sediment trap averages. The deep meter at SS- 3 (133 m) had a magnetic rotor follower problem and as a result collected no speed data for the entire deployment period. The operational channels of the instrument, however, have been plotted.

Appendix 2 is composed of progressive vector diagrams illustrating current direction and relative speed against the Julian date. Plotted symbols are described in the key and a reference mark to true north drawn. No plot is available for SS-3 at 133 m.

The last Appendix contains 16 day average values computed from current meter data segments which have been selected to match the timing of the sequential sediment trap cycles. Every 16 days, starting shortly after deployment, an empty receptacle was moved under the collection cone of the sediment trap. After 10 or 13 cycles, depending on the trap type, a 100 or 130 day time series of sediment samples was collected. Condensing the physical oceanographic data through averaging, to match the temporal resolution of the sediment time series, allows a direct comparison of biological and physical parameters within identical time segments.

4 References

Barnes, P.W., D.M. Rearic, and E. Reimnitz, 1984. Ice Gouging Characteristics and Processes. In: *The Alaskan Beaufort Sea: Ecosystems and Environment*. P.W. Barnes, D.M. Schell, and E. Reimnitz, Eds., Academic Press, New York, 185-212.

Bell, W.H., 1977. Static Analysis of Single Point Moorings. *Pac. Mar. Sci. Rep.*, **79-20**, 63 pp.

Gilbert, G. and K. Pederson, 1986. Ice Scour Data Base for the Beaufort Sea. Environmental Studies Revolving Funds, Report No. 055. Ottawa, 99 pp.

Lewis, E.L., and R.G. Perkin, 1978. The Practical Salinity Scale 1978: conversion of existing data. *Deep Sea Res.*, **28 A**, 307-328

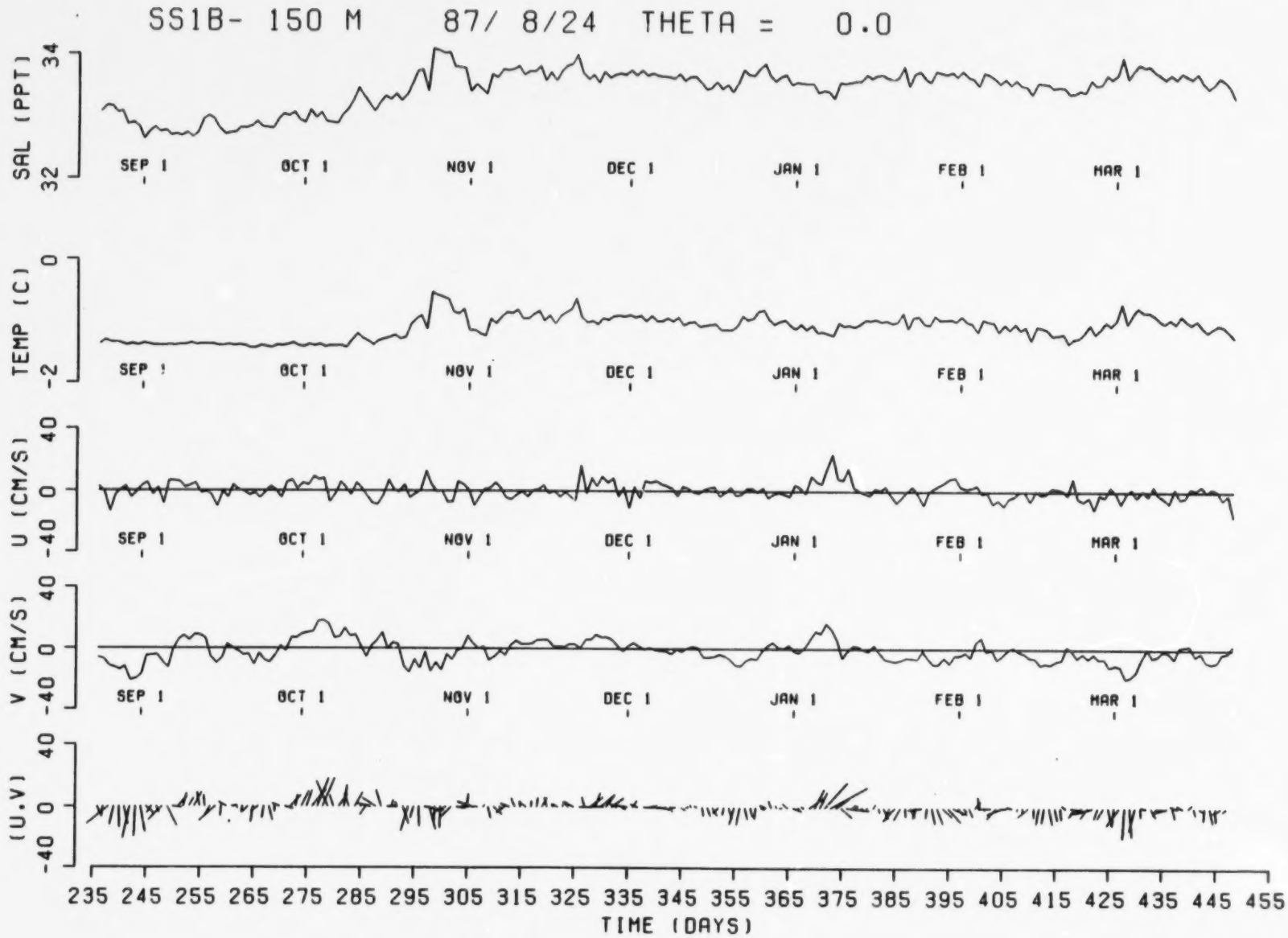
McCullough, D., R.W. Macdonald, K. Iseki, and E.C. Carmack, 1988. NOGAP B.6; Volume 1: Beaufort Sea current measurements, March-August 1987. *Can. Data Rep. Hydrogr. Ocean Sci.:* **60(1)**, 42pp.

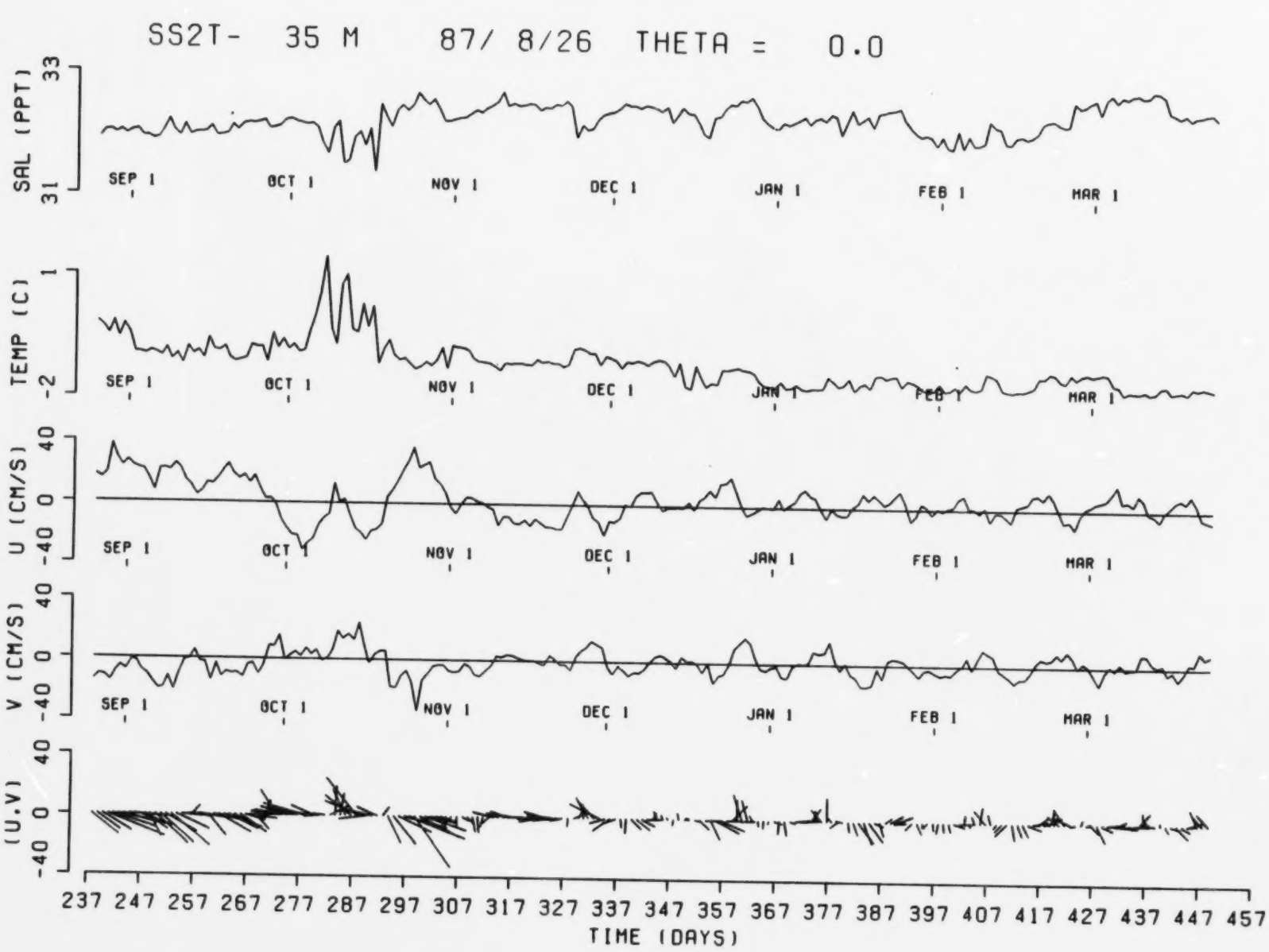
Merrill, R.T., and M.W. McElhinny, 1983. The Earth's Magnetic Field, Academic Press, London, 401 pp.

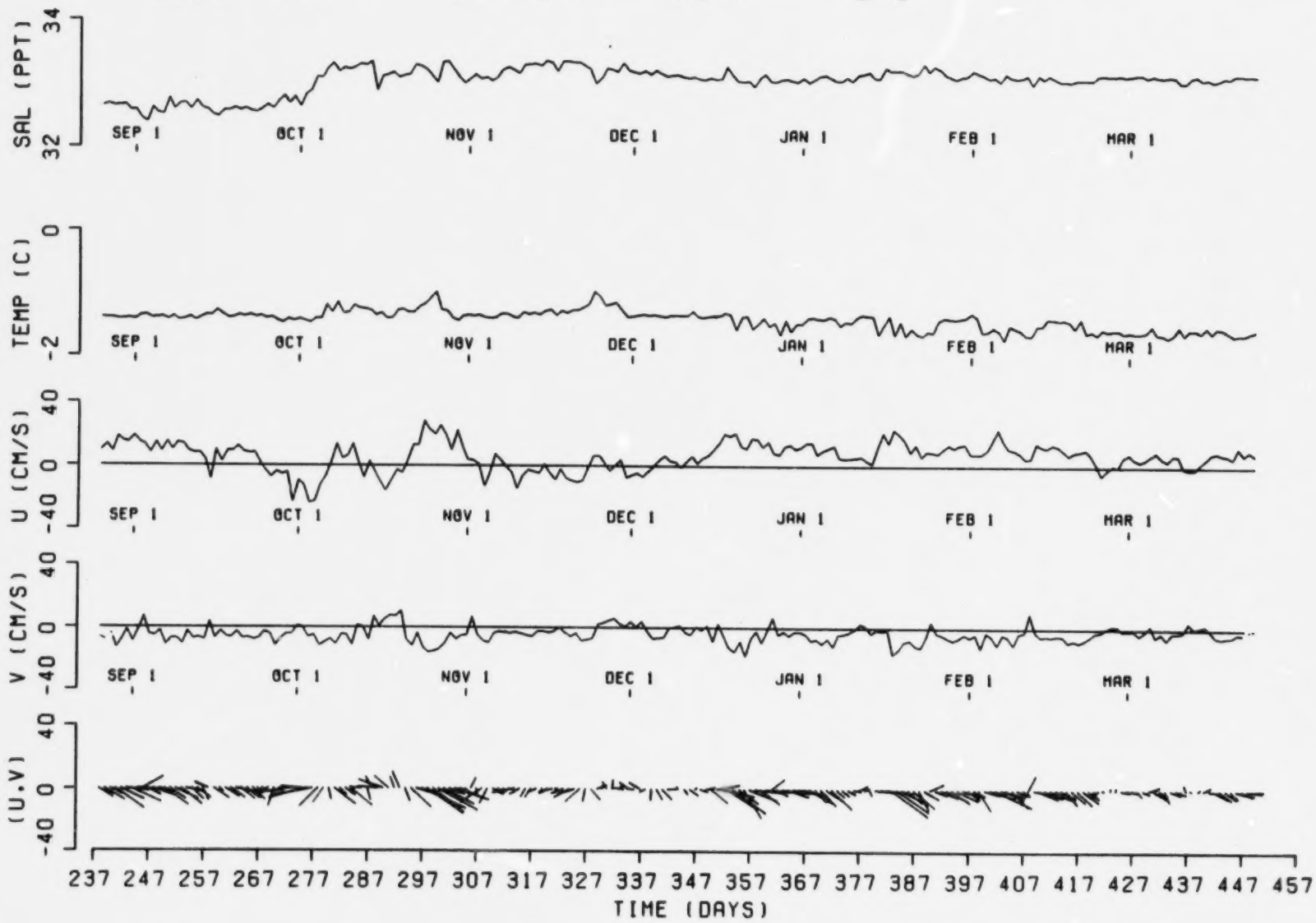
Woodward, M.J. and W.S. Huggett, 1979. Performance of Deep Subsurface Current Meter Moorings, *Lighthouse; Proceedings of the 19th Annual Canadian Hydrographic Conference*, 124- 130.

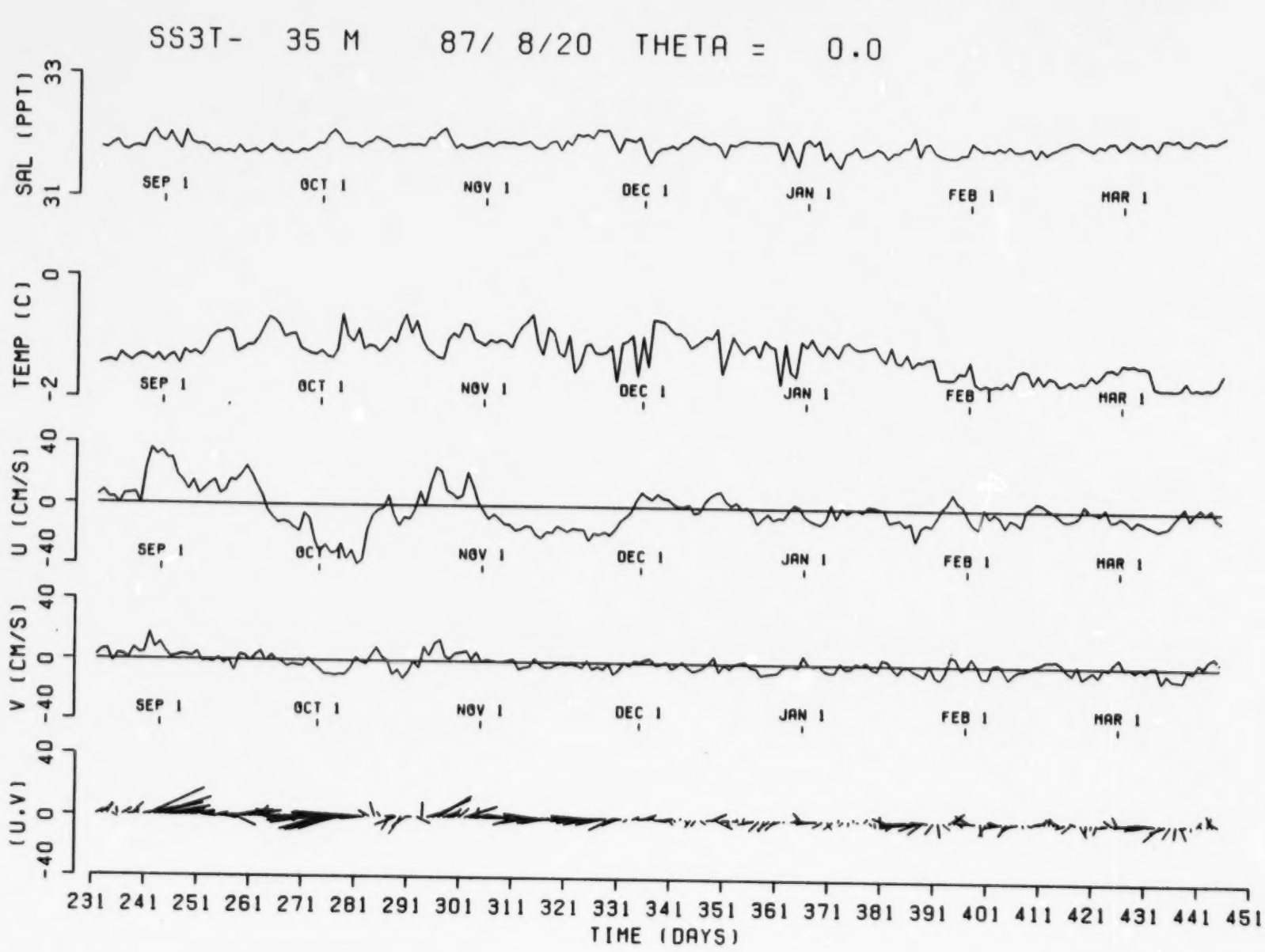
APPENDIX 1; TIME SERIES U-V STICK PLOTS

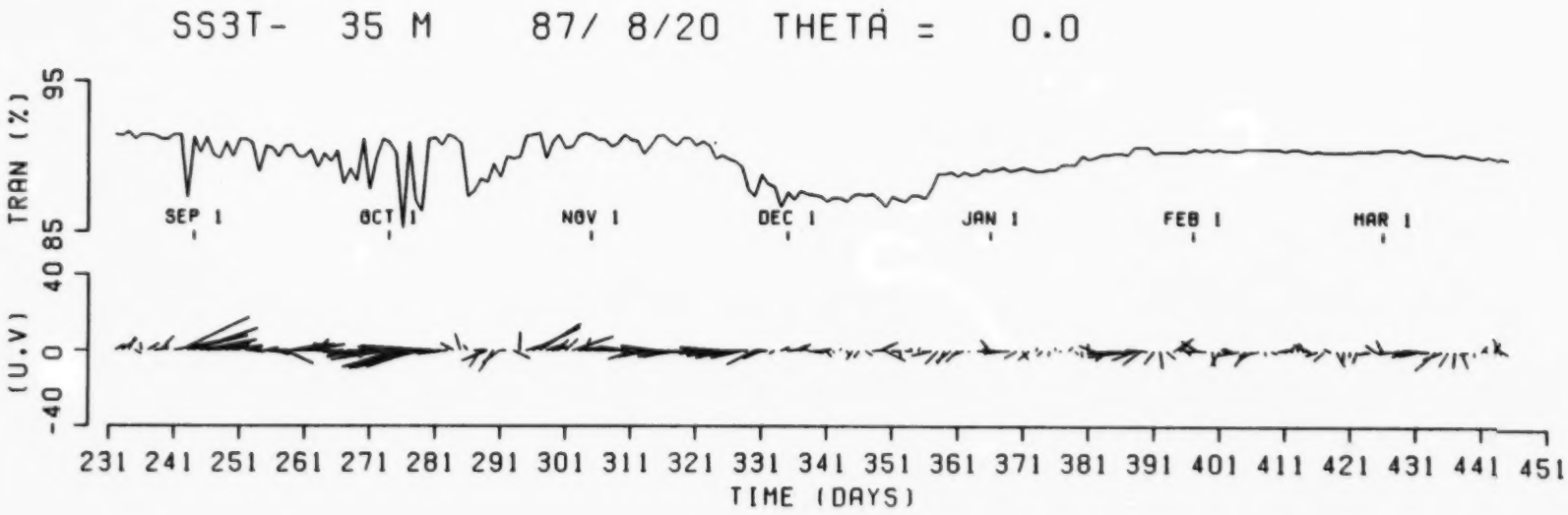
SSIT- 35 M 87/ 8/24 THETA = 0.0
SAL (PPT)
30 33
SEP 1
TEMP (C)
-2 2
SEP 1
U (CM/S)
-30 0 30
SEP 1
V (CM/S)
-30 0 30
SEP 1
(U,V)
-30 0 30
235 245 255
TIME (DAYS)

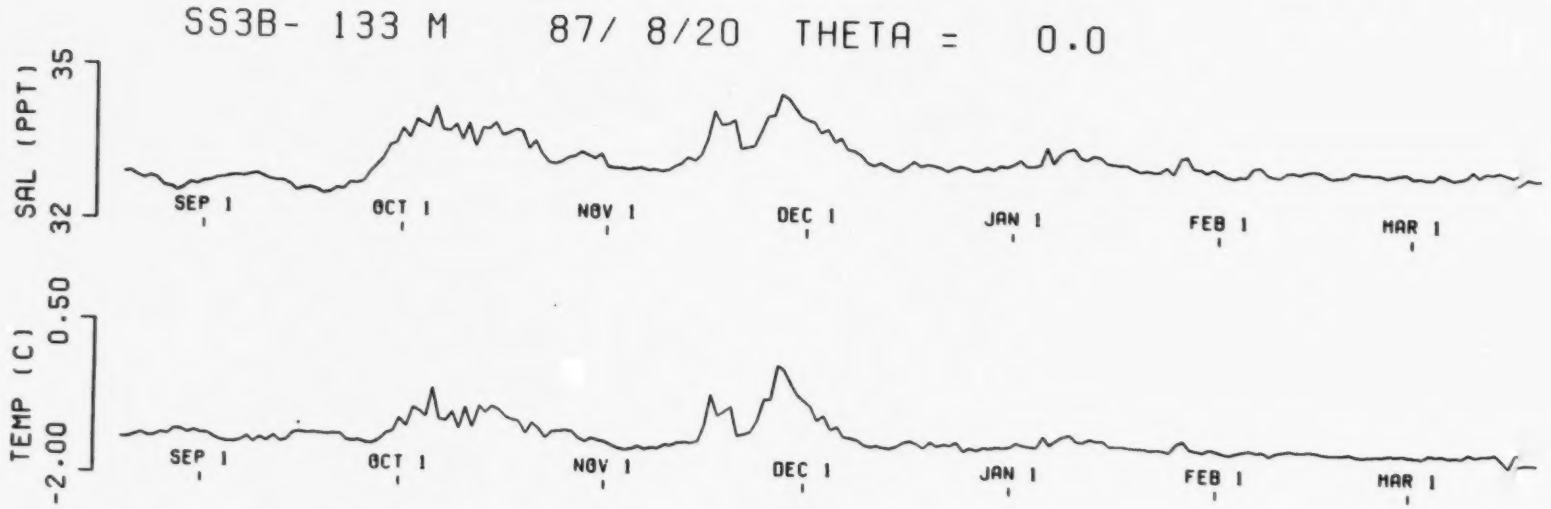

SS1B- 150 M 87/ 8/24 THETA = 0.0
SAL (PPT)
34
32
TEMP (C)
0
-2
U (CM/S)
40
0
-40
V (CM/S)
40
0
-40
(U.V)
40
0
-40
SEP 1
OCT 1
NOV 1
DEC 1
JAN 1
FEB 1
MAR 1
235 245 255 265 275 285 295 305 315 325 335 345 355 365 375 385 395 405 415 425 435 445 455
TIME (DAYS)

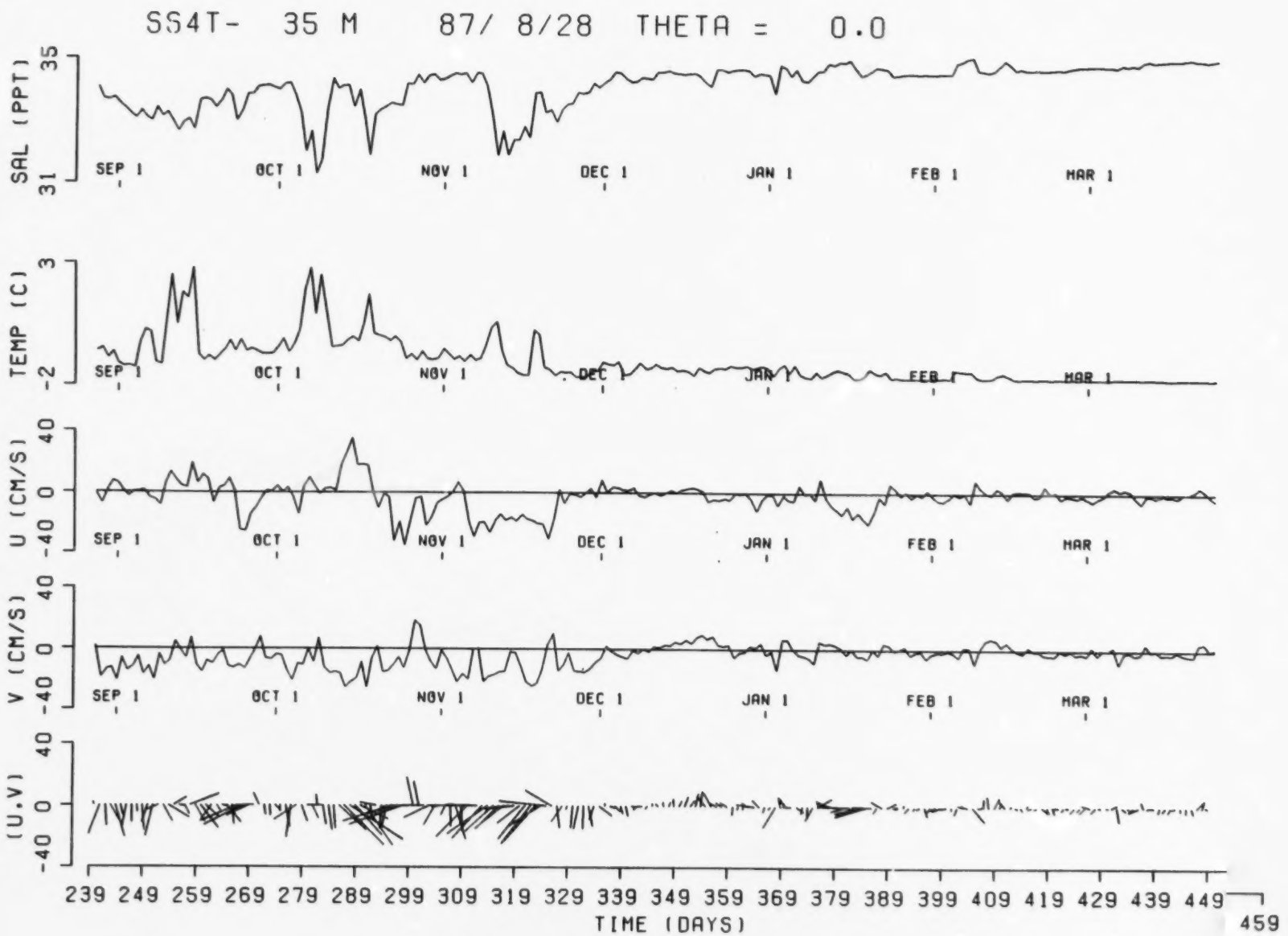

SS2T- 35 M 87/ 8/26 THETA = 0.0
SAL (PPT)
33
31
TEMP (C)
1
-2
U (CM/S)
40
0
-40
V (CM/S)
40
0
-40
(U,V)
40
0
-40
SEP 1
OCT 1
NOV 1
DEC 1
JAN 1
FEB 1
MAR 1
237 247 257 267 277 287 297 307 317 327 337 347 357 367 377 387 397 407 417 427 437 447 457
TIME (DAYS)

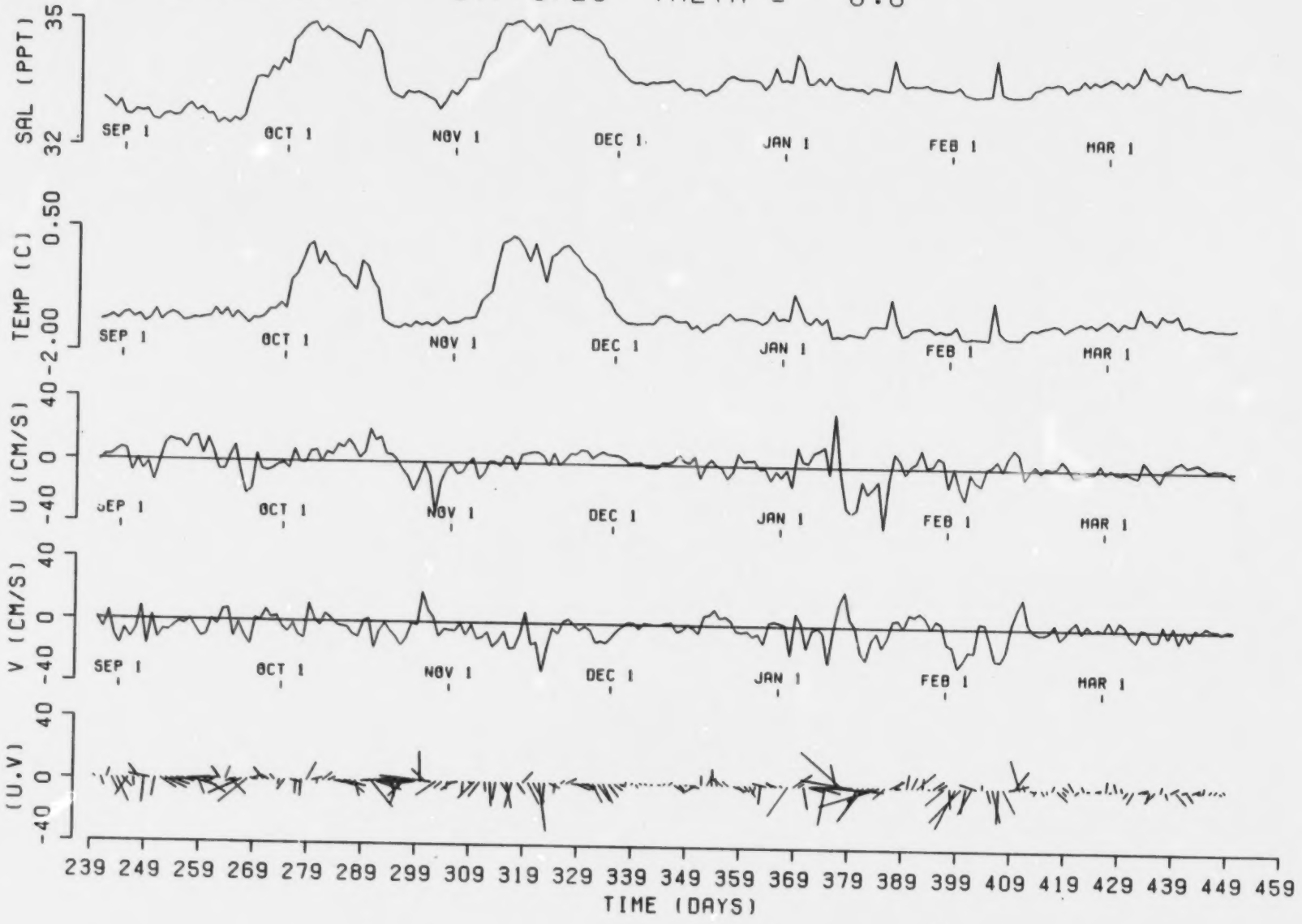

SS2B- 120 M 87/ 8/26 THETA = 0.0
SAL (PPT)
34
32
TEMP (C)
0
-2
U (CM/S)
40
0
-40
V (CM/S)
40
0
-40
(U.V)
40
0
-40
SEP 1
OCT 1
NOV 1
DEC 1
JAN 1
FEB 1
MAR 1
237 247 257 267 277 287 297 307 317 327 337 347 357 367 377 387 397 407 417 427 437 447 457
TIME (DAYS)


SS3T- 35 M 87/ 8/20 THETA = 0.0
SAL (PPT)
33
31
TEMP (C)
0
-2
U (CM/S)
40
0
-40
V (CM/S)
40
0
-40
(U,V)
40
0
-40
SEP 1
OCT 1
NOV 1
DEC 1
JAN 1
FEB 1
MAR 1
231 241 251 261 271 281 291 301 311 321 331 341 351 361 371 381 391 401 411 421 431 441 451
TIME (DAYS)

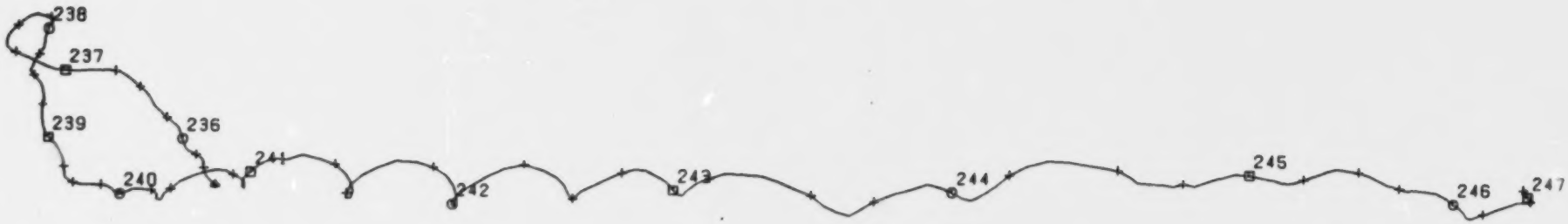

SS3T- 35 M 87/ 8/20 THETA = 0.0
TRAN (%)
95
85
SEP 1
OCT 1
NOV 1
DEC 1
JAN 1
FEB 1
MAR 1
(U,V)
40
0
-40
231 241 251 261 271 281 291 301 311 321 331 341 351 361 371 381 391 401 411 421 431 441 451
TIME (DAYS)


SS3B- 133 M 87/ 8/20 THETA = 0.0
SAL (PPT)
35
32
SEP 1
OCT 1
NOV 1
DEC 1
JAN 1
FEB 1
MAR 1
TEMP (C)
0.50
-2.00
SEP 1
OCT 1
NOV 1
DEC 1
JAN 1
FEB 1
MAR 1


SS4T- 35 M 87/ 8/28 THETA = 0.0
SAL (PPT)
35
31
TEMP (C)
3
-2
U (CM/S)
40
0
-40
V (CM/S)
40
0
-40
(U,V)
40
0
-40
SEP 1
OCT 1
NOV 1
DEC 1
JAN 1
FEB 1
MAR 1
239 249 259 269 279 289 299 309 319 329 339 349 359 369 379 389 399 409 419 429 439 449
459
TIME (DAYS)


SS4B- 150 M 87/ 8/28 THETA = 0.0
SAL (PPT)
35
32
TEMP (C)
0.50
-2.00
U (CM/S)
40
0
-40
V (CM/S)
40
0
-40
(U.V)
40
0
-40
SEP 1
OCT 1
NOV 1
DEC 1
JAN 1
FEB 1
MAR 1
239 249 259 269 279 289 299 309 319 329 339 349 359 369 379 389 399 409 419 429 439 449 459
TIME (DAYS)

APPENDIX 2; PROGRESSIVE VECTOR PLOTS



20

BEAUFORT SEA SHELF 70-45.* 127-23.*
PROGRESSIVE VECTOR DIAGRAM

△START OF OBSERVATIONS
□ODD NUMBERED DAYS
○EVEN NUMBERED DAYS
+SIX HOUR INTERVAL

STN	DEPTH	ID	START	NO DAYS
SSITOP	40.0 M	7906	235/87	12

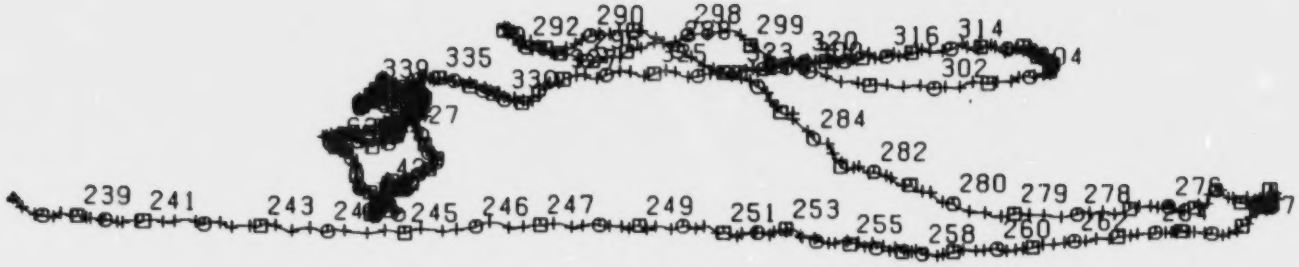
SCALE 10 KM

BEAUFORT SEA SHELF 70-45.* 127-23.*
PROGRESSIVE VECTOR DIAGRAM

△START OF OBSERVATIONS
□ODD NUMBERED DAYS
○EVEN NUMBERED DAYS
+SIX HOUR INTERVAL

STN	DEPTH	ID	START	NO DAYS
SS1B0T	150.0 M	7914	235/87	214

SCALE
10 KM



BEAUFORT SEA SHELF 70-27.* 128-39.*
PROGRESSIVE VECTOR DIAGRAM

△START OF OBSERVATIONS
□ODD NUMBERED DAYS
○EVEN NUMBERED DAYS
+SIX HOUR INTERVAL

STN	DEPTH	ID	START	NO DAYS
SS2TOP	40.0 M	7911	237/87	213

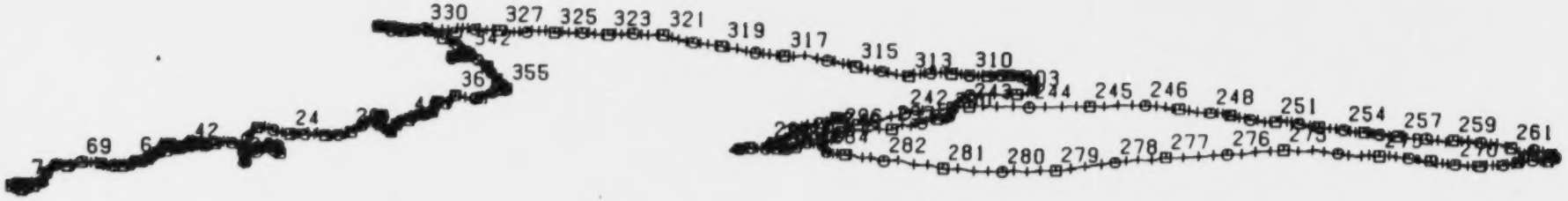
SCALE
10 KM

BEAUFORT SEA SHELF 71-27.* 128-39.*
PROGRESSIVE VECTOR DIAGRAM

△START OF OBSERVATIONS
□ODD NUMBERED DAYS
○EVEN NUMBERED DAYS
+SIX HOUR INTERVAL

STN	DEPTH	ID	START	NO DAYS
SS2B0T	120.0 M	7915	237/87	213

SCALE
10 KM



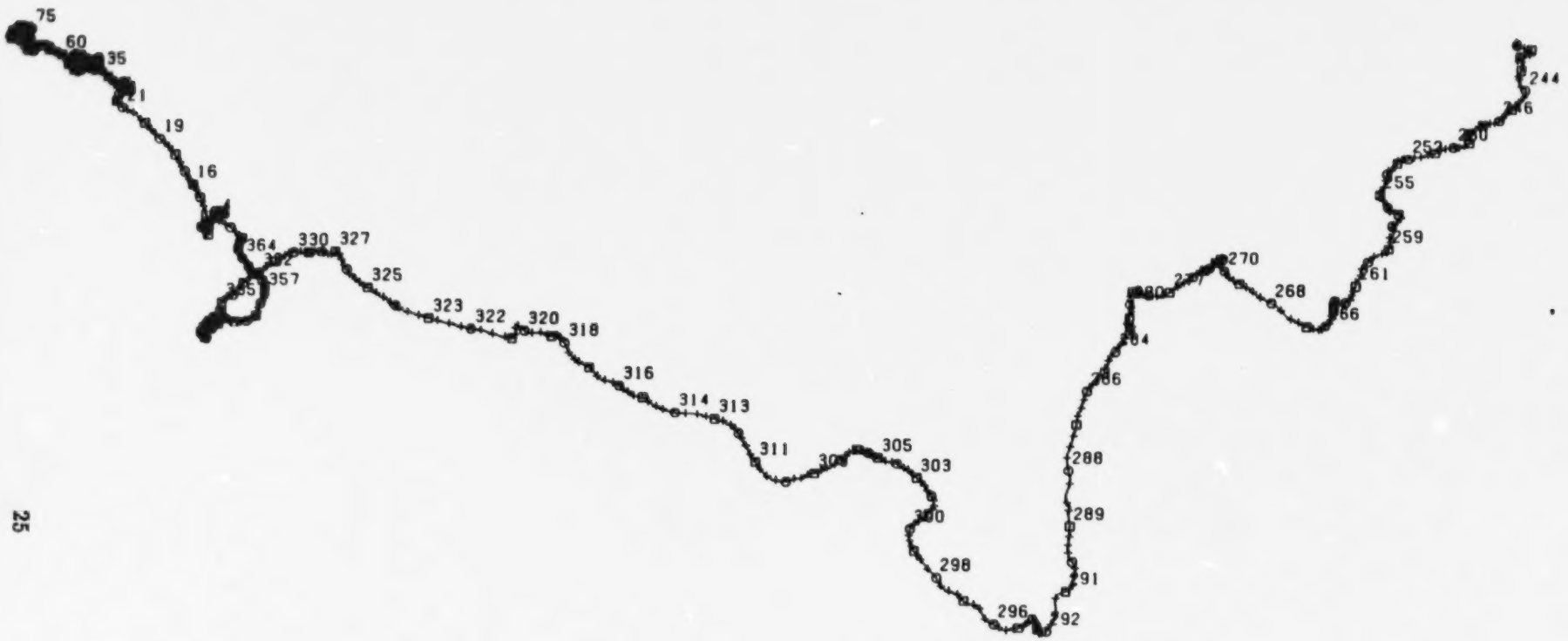
BEAUFORT SEA SHELF 70-57.* 134-23.*
PROGRESSIVE VECTOR DIAGRAM

△START OF OBSERVATIONS
□ODD NUMBERED DAYS
○EVEN NUMBERED DAYS
+SIX HOUR INTERVAL

STN	DEPTH	ID	START	NO DAYS
SS3TOP	40.0M	7907	231/87	215

SCALE
10 KM

N

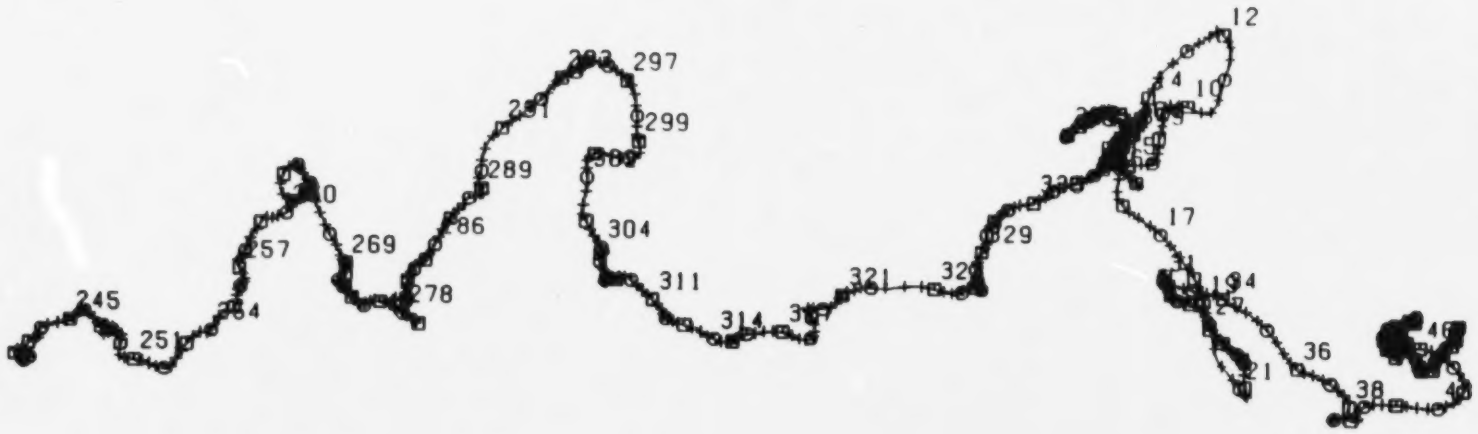


BEAUFORT SEA SHELF 69-50.* 138-29.*
PROGRESSIVE VECTOR DIAGRAM

△START OF OBSERVATIONS
□ODD NUMBERED DAYS
○EVEN NUMBERED DAYS
+SIX HOUR INTERVAL

STN	DEPTH	ID	START	NO DAYS
SS4TOP	35.0 M	7913	239/87	212

SCALE
10 KM



BEAUFORT SEA SHELF 69-50.* 138-29.*
PROGRESSIVE VECTOR DIAGRAM

△START OF OBSERVATIONS
□ODD NUMBERED DAYS
○EVEN NUMBERED DAYS
+SIX HOUR INTERVAL

STN	DEPTH	ID	START	NO DAYS
SS4BOT	150.0 M	7918	239/87	212

SCALE
10 KM

APPENDIX 3; 10 DAY AVERAGES PLOTS AND TABLES

The 10 day periods have been chosen to coincide with the sequential sediment trap collection intervals.

16 Day Averages Matching Trap Cycles (1988)

Station SS-1 150 Meters

Sal	Temp	Dir	Speed	%TX	Start	End
32.81	-1.39	201.92	9.47	0.00	244	260
32.92	-1.40	184.02	7.00	0.00	260	276
33.17	-1.32	220.71	12.22	0.00	276	292
33.68	-0.94	200.03	8.45	0.00	292	308
33.73	-0.91	234.55	5.21	0.00	308	324
33.73	-0.93	172.12	7.36	0.00	324	340
33.61	-1.01	205.42	4.68	0.00	340	356
33.61	-1.02	203.55	6.85	0.00	356	7
33.65	-1.00	176.57	7.95	0.00	7	23
33.70	-0.97	197.79	7.08	0.00	23	39
33.54	-1.12	215.97	7.50	0.00	39	55
33.74	-0.93	224.59	9.25	0.00	55	71
33.63	-1.02	225.74	6.57	0.00	71	87

Station SS-2 35 Meters

Sal	Temp	Dir	Speed	%TX	Start	End
32.02	-0.87	120.51	20.72	0.00	243	259
32.13	-0.81	166.83	14.52	0.00	259	275
31.98	-0.08	289.19	20.83	0.00	275	291
32.39	-0.96	141.96	19.23	0.00	291	307
32.46	-1.08	270.91	12.10	0.00	307	323
32.35	-0.95	241.87	12.94	0.00	323	339
32.36	-1.30	182.07	7.17	0.00	339	355
32.37	-1.46	191.89	9.47	0.00	355	6
32.31	-1.53	199.64	9.10	0.00	6	22
32.05	-1.56	200.65	6.92	0.00	22	38

Station SS-2 120 Meters

Sal	Temp	Dir	Speed	%TX	Start	End
32.59	-1.38	129.06	13.00	0.00	243	259
32.67	-1.40	203.79	11.17	0.00	259	275
33.15	-1.32	233.01	11.40	0.00	275	291
33.17	-1.29	145.72	14.78	0.00	291	307
33.21	-1.34	257.42	9.87	0.00	307	323
33.22	-1.25	242.19	9.21	0.00	323	339
33.09	-1.36	148.21	9.35	0.00	339	355
33.07	-1.44	105.69	10.03	0.00	355	6
33.14	-1.51	107.63	9.46	0.00	6	22
33.15	-1.48	111.99	11.13	0.00	22	38

Station SS-3 35 Meters

Sal	Temp	Dir	Speed	%TX	Start	End
31.83	-1.16	82.99	15.95	90.52	244	260
31.80	-0.99	219.43	15.27	89.52	260	276
31.90	-1.00	229.47	18.60	89.73	276	292

31.92	-1.04	124.74	12.15	91.00	292	308
31.94	-1.05	262.19	15.31	91.09	308	324
31.92	-1.10	184.38	10.63	88.20	324	340
31.96	-1.00	154.39	4.91	87.34	340	356
31.89	-1.11	216.10	6.67	89.02	356	7
31.86	-1.14	206.68	5.57	89.80	7	23
31.88	-1.53	200.79	7.86	90.52	23	39
31.95	-1.56	184.36	6.68	90.53	39	55
32.03	-1.47	232.86	7.05	90.49	55	71
32.07	-1.67	183.80	6.48	89.96	71	87

Station SS-3 133 Meters

Sal	Temp	Dir	Speed	%TX	Start	End
32.85	-1.40	91.03	8.21	0.00	244	260
33.05	-1.32	243.88	1.50	0.00	260	276
33.91	-0.91	239.10	1.50	0.00	276	292
33.34	-1.27	155.38	4.73	0.00	292	308
33.49	-1.22	276.56	1.50	0.00	308	324
34.03	-0.78	166.93	1.50	0.00	324	340
33.35	-1.30	173.92	1.50	0.00	340	356
33.33	-1.33	252.45	1.50	0.00	356	7
33.43	-1.26	168.60	1.50	0.00	7	23
33.31	-1.34	177.20	1.50	0.00	23	39
33.26	-1.37	170.33	1.50	0.00	39	55
33.25	-1.38	247.57	1.50	0.00	55	71
33.38	-1.33	198.26	1.50	0.00	71	87

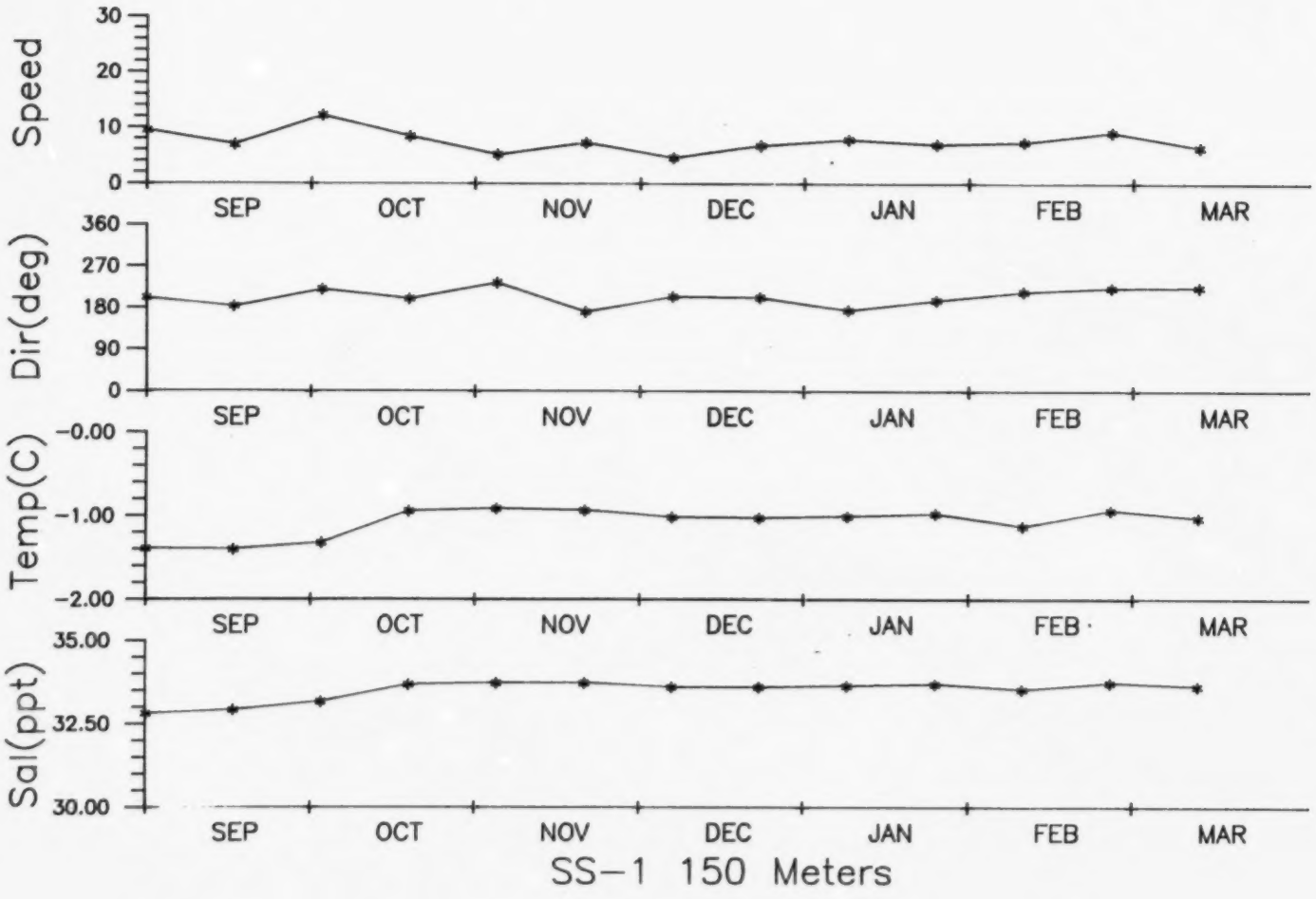
Station SS-4 35 Meters

Sal	Temp	Dir	Speed	%TX	Start	End
33.14	0.25	154.63	13.88	0.00	244	260
33.80	-0.57	190.87	11.94	0.00	260	276
33.19	0.56	146.09	20.23	0.00	276	292
34.08	-0.57	241.36	16.31	0.00	292	308
33.34	-0.72	225.75	23.31	0.00	308	324
33.96	-1.35	179.01	10.72	0.00	324	340
34.48	-1.27	194.02	4.77	0.00	340	356
34.59	-1.30	242.96	6.55	0.00	356	7
34.69	-1.49	232.12	10.27	0.00	7	23
34.64	-1.59	220.16	4.03	0.00	23	39

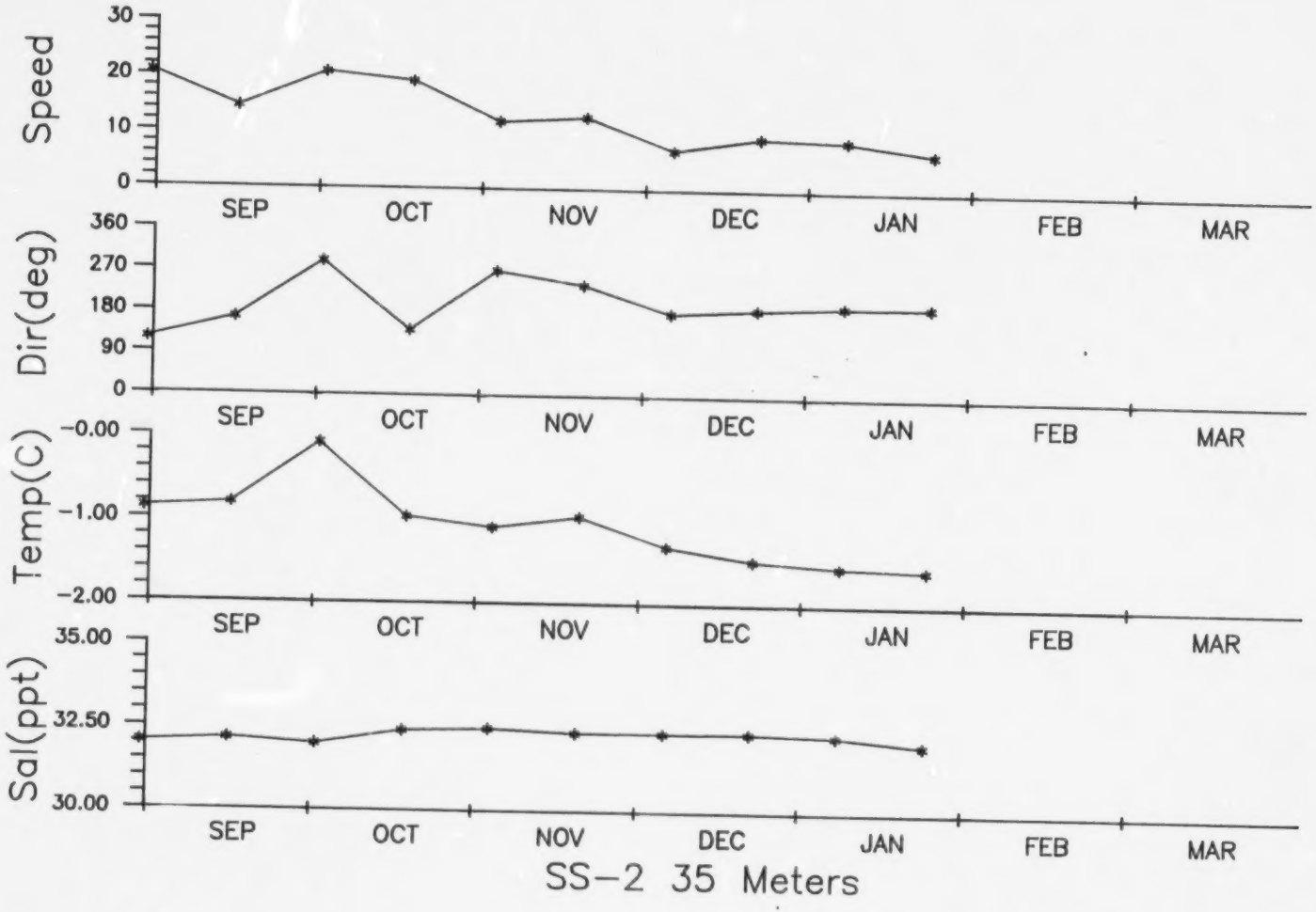
Station SS-4 150 Meters

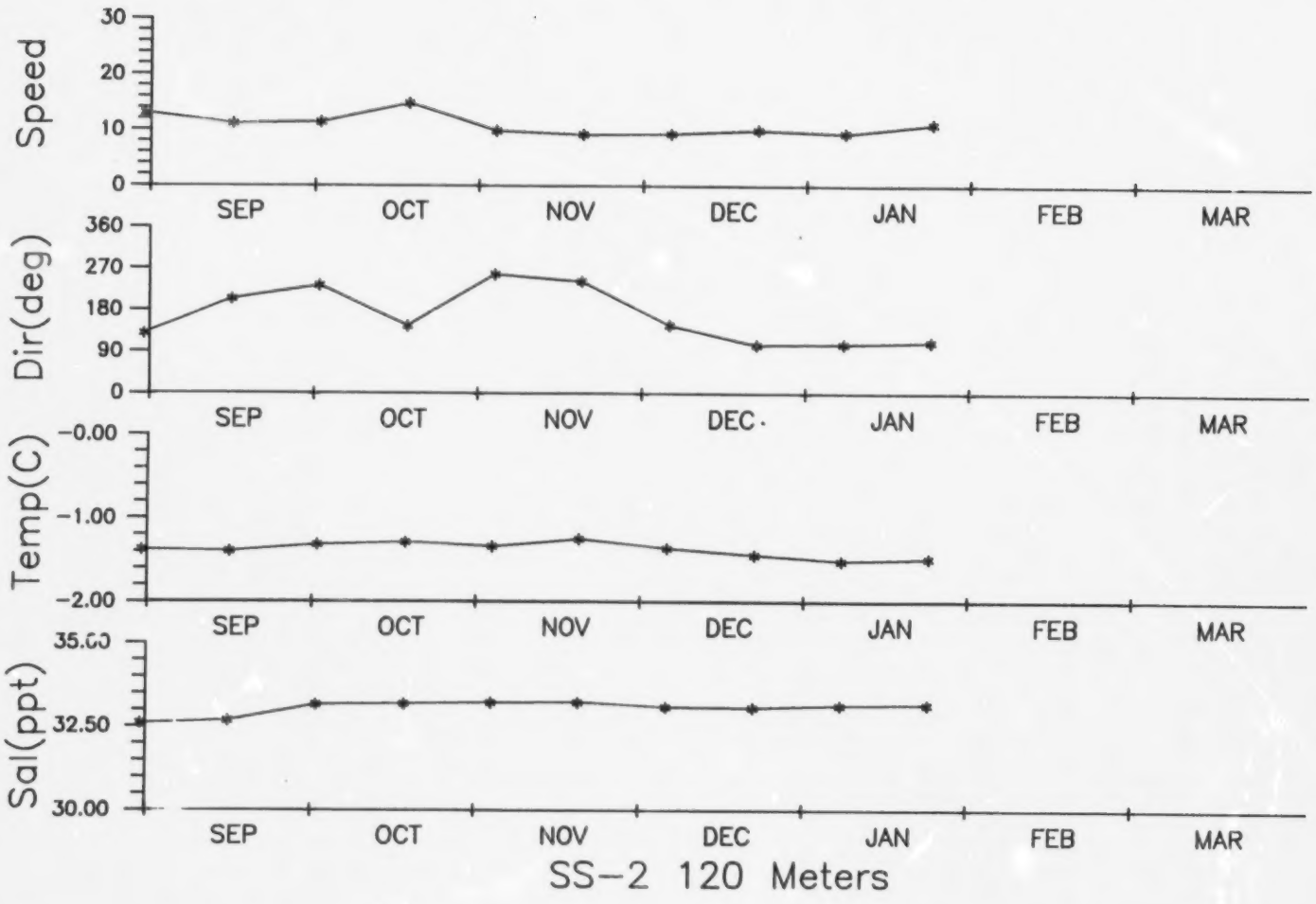
Sal	Temp	Dir	Speed	%TX	Start	End
32.78	-1.29	155.64	12.47	0.00	244	260
33.40	-1.12	195.51	9.60	0.00	260	276
34.63	-0.33	122.78	12.11	0.00	276	292
33.31	-1.38	213.81	11.30	0.00	292	308
34.68	-0.20	164.20	13.08	0.00	308	324
34.35	-0.62	120.05	6.89	0.00	324	340
33.59	-1.29	163.05	4.92	0.00	340	356
33.80	-1.16	189.54	8.09	0.00	356	7
33.68	-1.37	187.94	20.27	0.00	7	23

33.55	-1.44	146.06	11.98	0.00	23	39

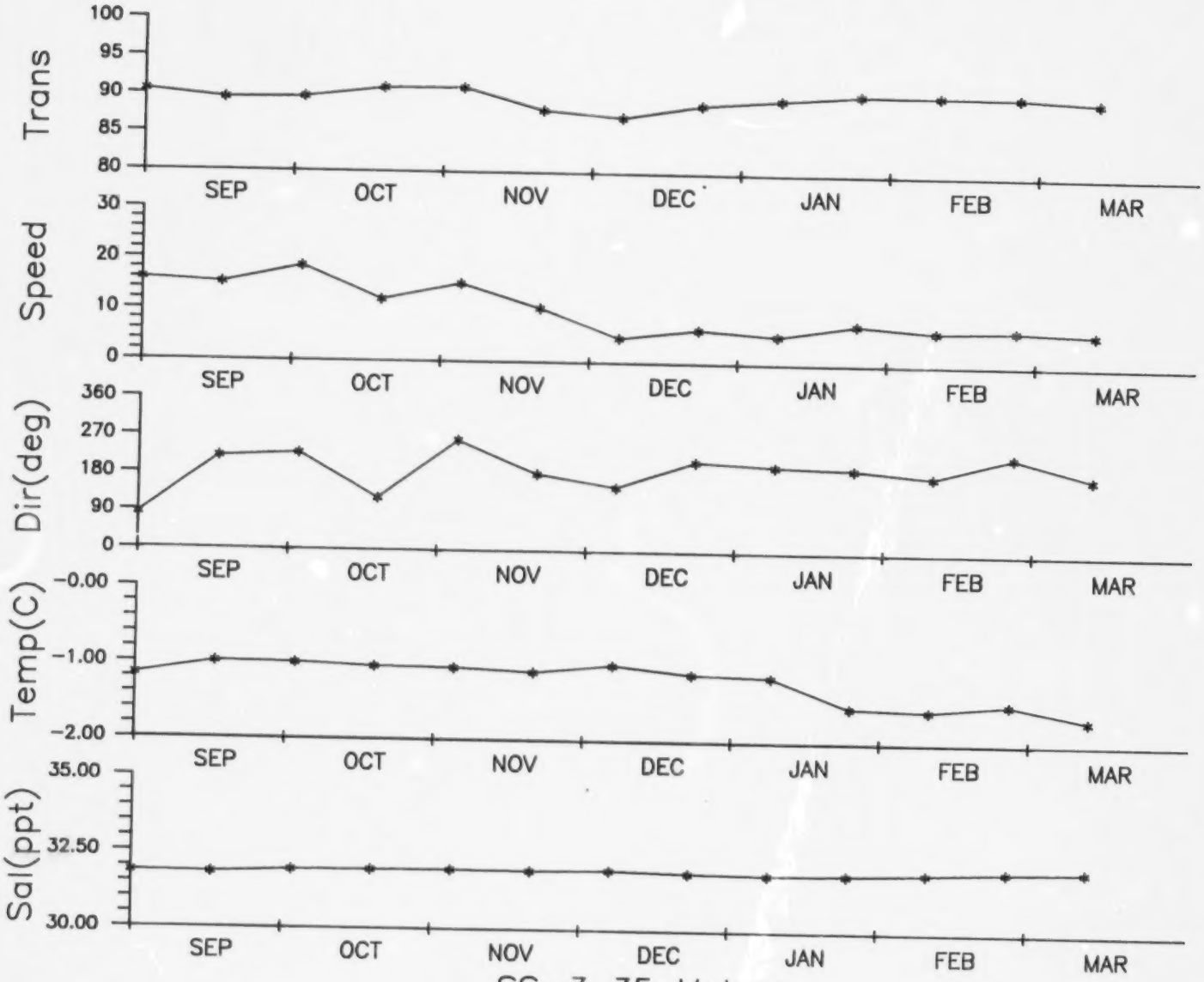


SS-1 150 Meters

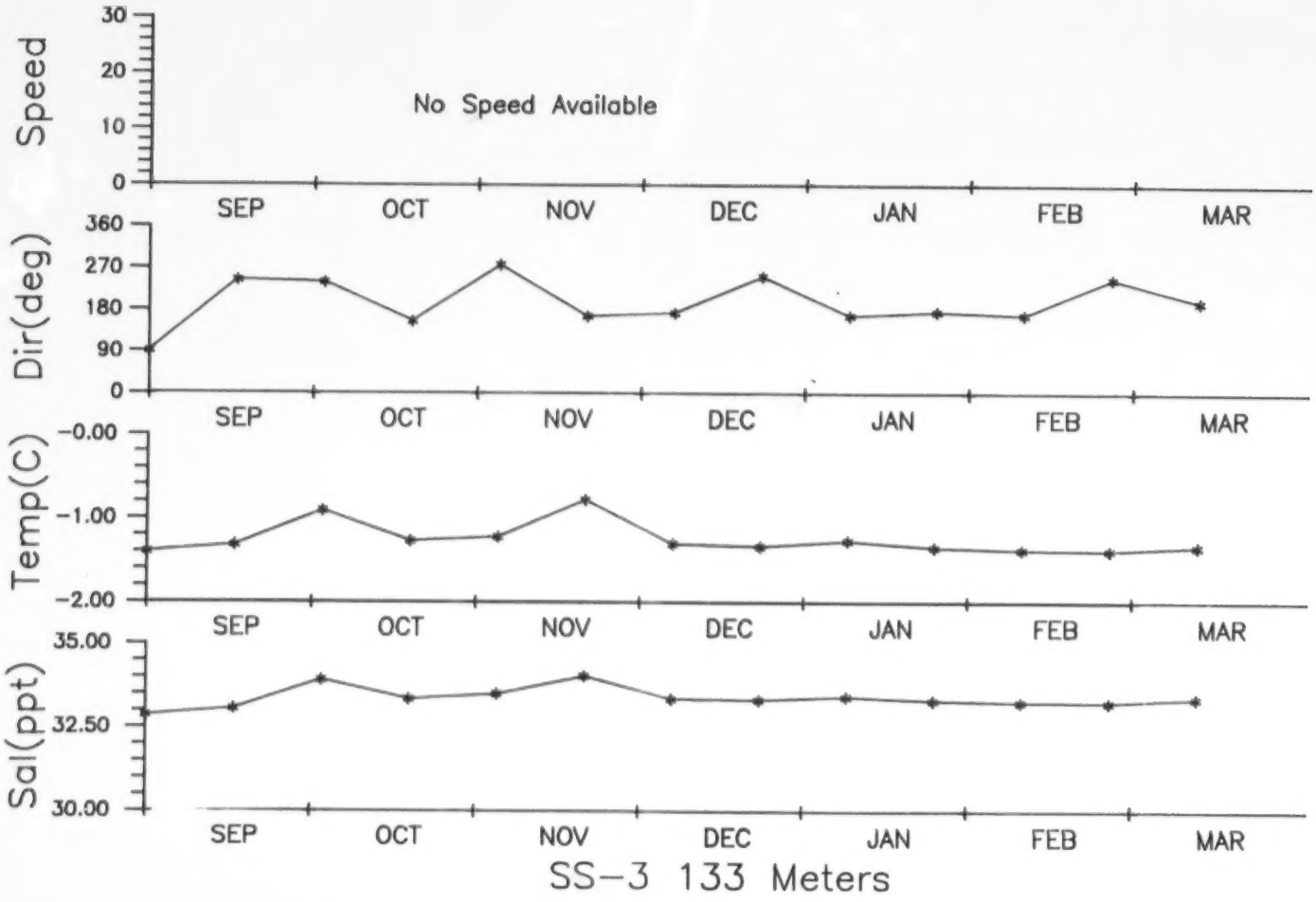

Speed
30
20
10
0
SEP
OCT
NOV
DEC
JAN
FEB
MAR
Dir(deg)
360
270
180
90
0
Temp(C)
-0.00
-1.00
-2.00
Sal(ppt)
35.00
32.50
30.00
SS-2 35 Meters



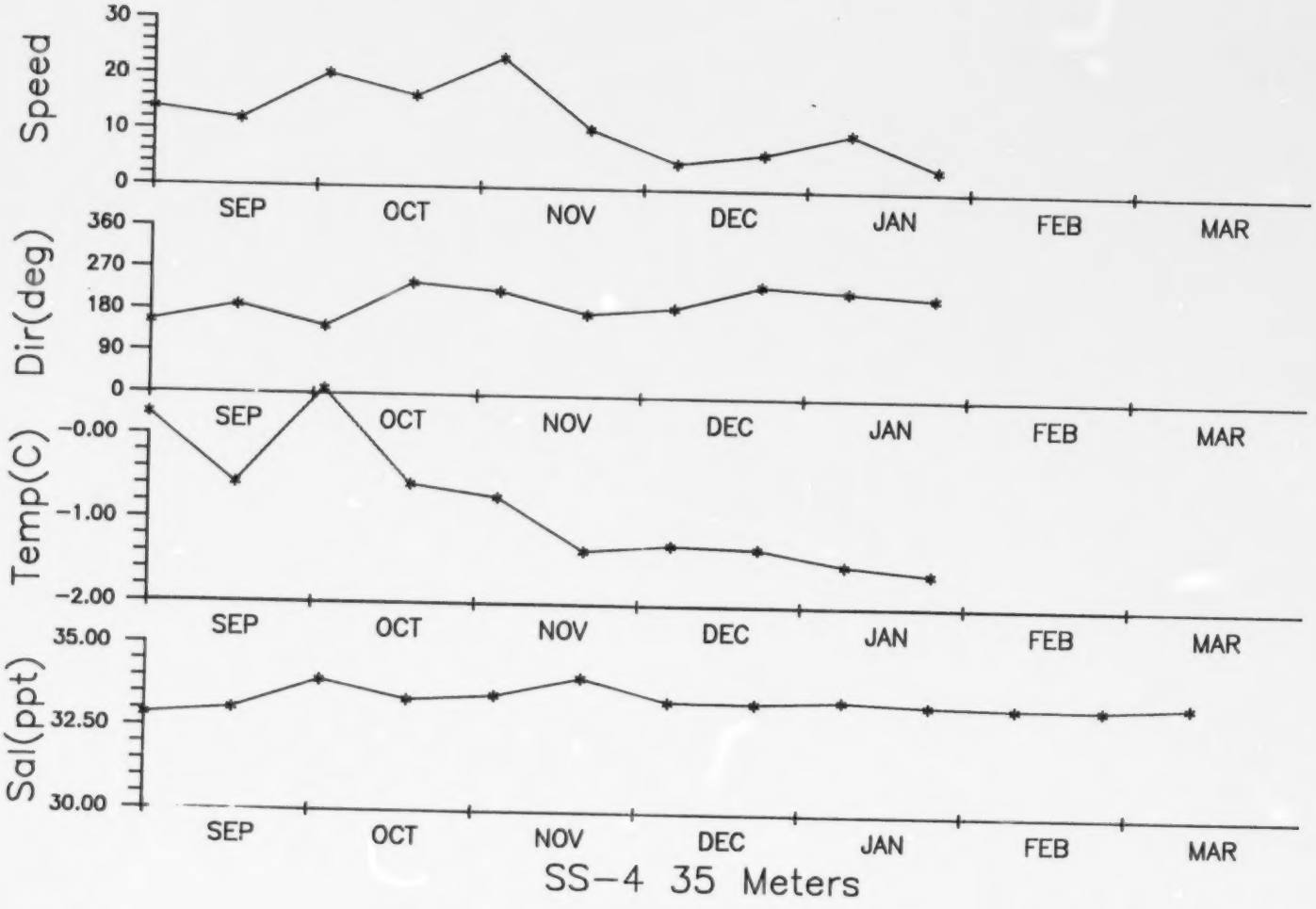
SS-2 120 Meters



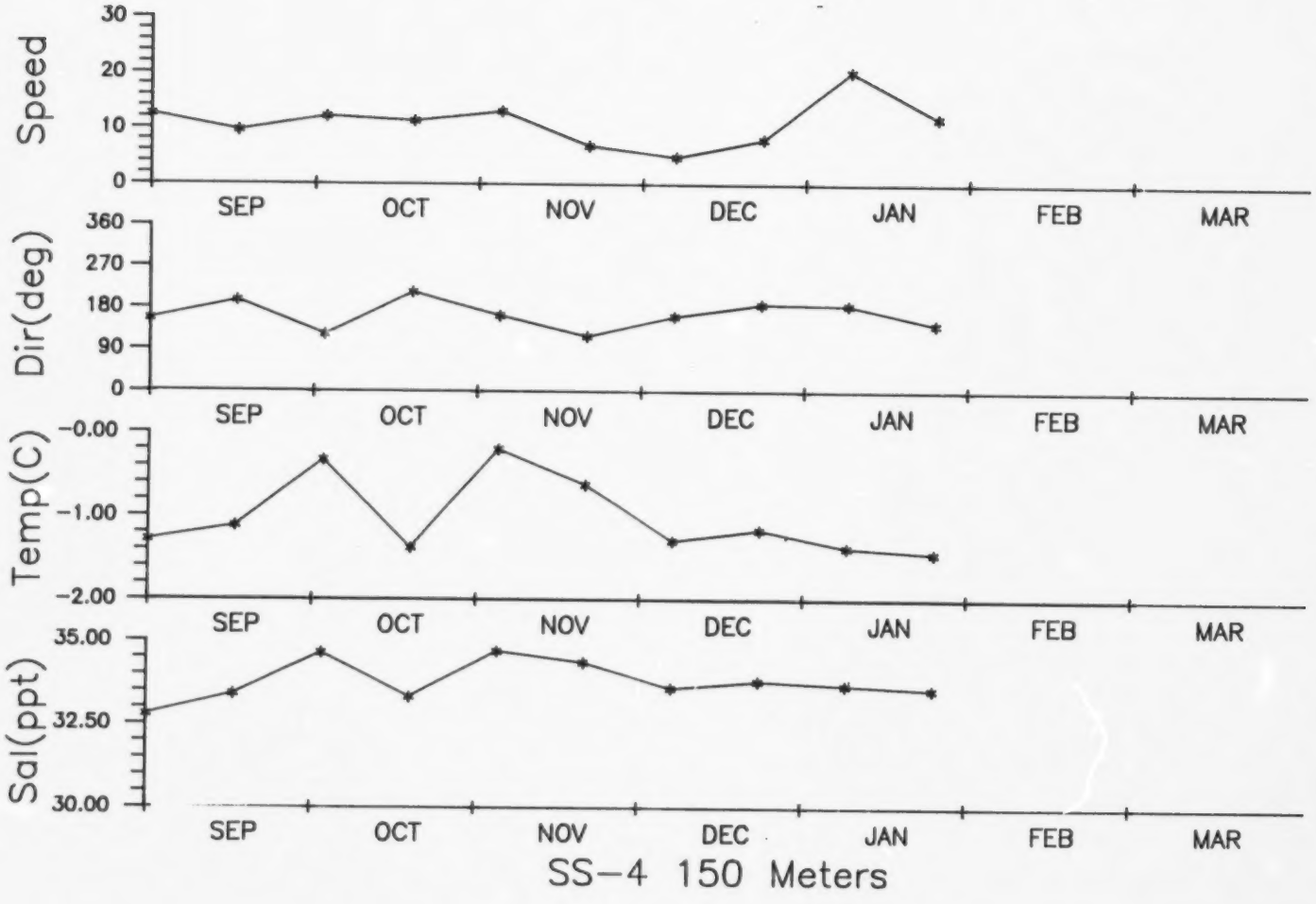
SS-3 35 Meters



SS-3 133 Meters



SS-4 35 Meters



SS-4 150 Meters

NOGAP B.6 Data Reports in the Canadian Data Report of Hydrography and Ocean Sciences Series

Macdonald, R.W., K. Iseki, E.C. Carmack, D.M. Macdonald, M.C. O'Brien, and F.A. McLaughlin, 1988. Data Report: NOGAP B.6; Beaufort Sea Oceanography, September, 1986. *Can. Data Rep. Hydrogr. Ocean Sci.:* **58**, 68pp.

Cuypers, L.E., A.W. Blaskovich, E.C. Carmack, and R.W. Macdonald, 1988. NOGAP B.6; Physical data collected in the Beaufort Sea, September, 1986. *Can. Data Rep. Hydrogr. Ocean Sci.:* **59**, 149pp.

McCullough, D., R.W. Macdonald, K. Iseki, and E.C. Carmack, 1988. NOGAP B.6; Volume 1: Beaufort Sea current measurements, March-August 1987. *Can. Data Rep. Hydrogr. Ocean Sci.:* **60(1)**, 42pp.

Macdonald, D.M., L.E. Cuypers, D.McCullough, E. Carmack, and R.W. Macdonald, 1988. NOGAP B.6; Volume 2: Physical data collected in the Beaufort Sea, March-June 1987 em Can. Data Rep. Hydrogr. Ocean Sci.: **60(2)**, 157pp.